

instance of the lower portion of the erection being inclosed by matting to form a "ground floor." Were these pile-dwellings confined to the low, flat lands upon which the Bengali delights to place his paddy-fields, it would be obvious that they were adopted for the purpose of obtaining a dry, wholesome floor, and security against unanticipated floods. But so far is this from being the case that only very rarely is a Naga or Kuki village to be found on low-lying ground, and generally they are to be seen upon the sides and even the summits of considerable elevations, where any danger from floods is quite out of the question. Again, it might be supposed that these elevated dwellings were adopted as a protection against wild animals but for a curious practice occasionally observable amongst the hill-men. This is the habit of building upon the steep side of a hill in such a manner that the back of the dwelling rests directly upon the ground, while the front is supported upon piles which are of a height sufficient to render the floor, throughout its length, horizontal. Such a plan as this reduces the protection afforded from vermin and wild animals to minimum, and seems to justify the belief that the fear of these creatures at least could have little or no influence upon the architectural habits of the hill-tribes of this part of India; and I long ago came to the conclusion that here at least the object of the pile-dwellings was simply to attain in the easiest way a floor which should be exempt from the damp exhalations of a tropical soil.

JAMES DALLAS

#### "Probable Nature of the Internal Symmetry of Crystals"

UNDER this head Mr. Barlow has published in *NATURE* of December 20 and 27, 1883 (pp. 186 and 205) an interesting and ingenious memoir. The subject being very important, but also very difficult and intricate, a discussion of the new theory may perhaps contribute to render our ideas a little more precise.

Whilst Häuy, Frankenheim, Delafosse, Bravais, and others think a crystal built up of mere congruent particles, which may be either the chemical molecules or rather certain aggregates of them, Mr. Barlow considers the arrangement of the different chemical atoms in the interior of a crystallised compound, and illustrates some facts by this manner of viewing them. I purpose in the following submitting some objections which arise against the deductions of the author. These objections are of a geometrical, chemical, and physical nature; let us begin with the geometrical ones.

The first problem of Mr. Barlow is "to inquire what very symmetrical arrangements of points or particles in space are possible." He comes to this result: "It would appear that there are but five." Then he describes these five arrangements. What conditions are to be fulfilled by an arrangement of points in space which is to be "very symmetrical," is nowhere said. According to this indefiniteness of the fundamental notion, the five kinds of very symmetrical arrangement seem to be found rather by divination than by systematic reasoning. Therefore the foundation of the theory appears somewhat arbitrary; and we may suspect that it is incomplete. We are in fact confirmed in this presumption if we consider the results of a geometric research published in my "Entwickelung einer Theorie der Krystallstruktur" (Leipzig: Teubner, 1879). In this book I have specified all possible arrangements of points that are regular and infinite, I have called a system of points *regular* if the points are disposed around every one point of the system in precisely the same manner as around every other. *There are sixty-six such regular systems of points possible.* According to the peculiarity of their symmetry they are subdivided into groups, which correspond strictly to the known crystallographic systems. Many of those arrangements of points have a hemihedral or tetartohedric character; others have the structure of a screw; and amongst the latter I could even suggest one particular system which represents the internal structure of quartz. The latter result was obtained (*loc. cit.* pp. 238-245) by comparing the crystallographic and optical properties of quartz with those of the known combination of thin laminae of mica arranged in the manner of winding-stairs, described by Prof. Reusch fourteen years ago. All sixty-six systems are in agreement with the principal law of crystallography, the law of rational segments of the axes (Wiedemann, *Annalen der Physik*, 1882, vol. xvi. p. 489). For example, if we have reason to suppose that a certain one of these systems should represent the structure of a given substance crystallising in hexagonal pyramids, then we derive geometrically the same series of possible pyramids which nature actually exhibits.

Four of Mr. Barlow's five kinds of "very symmetrical arrangements" prove to be extremely particular cases of four general systems of mine. The first, second, and third kinds of Mr. Barlow's result from the systems which I have called the "rhombododecahedral, cubic, and octahedral system with 24-points-aggregates" ("Entwickelung," pp. 165-168), if we suppose the twenty-four points of the so-called "24-punkter" coinciding in one point, and if we identify this point with the centre of a sphere of Mr. Barlow. Mr. Barlow's fourth kind of "very symmetrical arrangements" results as a particular case from my "3-gängiges 6-punkt-schraubensystem" (*loc. cit.*, Fig. 46), if the sides of all hexagons are supposed to touch one another, and the layers to have convenient distances. Mr. Barlow's fifth kind of symmetry, not being regular in the sense defined above, cannot be found amongst my sixty-six systems. Though every point is surrounded by six neighbouring points at equal distances, the latter have not throughout an identical arrangement. Every point of the first, third, fifth, &c., layers is situated at the centre of a perpendicular prism (with regular triangular base) whose angles bear the six neighbouring points of the system, but around every point of the second, fourth, sixth, &c., layers, the six neighbouring points are situated at the angles of two regular triangles, which do not lie parallel over one another as before, one of them being turned round in its plane 60°.

As my sixty-six systems comprise four of Mr. Barlow's kinds of symmetry, it may be expected that they include other arrangements besides, which may also pass as "very symmetrical." For example, in a cubic aggregate of points, the centres of the edges of all cubes determine a very symmetrical arrangement of points, where every point has equal distances from the next eight surrounding points (cf. "Entwickelung," &c., p. 160). From this I believe I have shown that the geometrical foundation of Mr. Barlow's theory is somewhat arbitrary and incomplete.

I now come to the chemical objections, which I will explain by an example. A chemical compound of two kinds of atoms, present in equal number—for example  $\text{NaCl}$ —could, according to Mr. Barlow, crystallise into the first or second of his five kinds of symmetry, for either of these two kinds allows the regular arrangement of two kinds of particles in equal number. In the first kind of symmetry (for example) spheres are so arranged that they constitute a cubic system of points, in which the centre of each cube bears also a point of the system. By putting atoms of one kind ( $\text{Na}$ ) on the angles, and atoms of the other kind ( $\text{Cl}$ ) on the centres of the cubes, we have built up the structure of a crystal of  $\text{NaCl}$ . Thus eight atoms of  $\text{Na}$  stand in exactly identical manner around an atom of  $\text{Cl}$  (and also eight atoms of  $\text{Cl}$  around an atom of  $\text{Na}$ ). The atom of  $\text{Cl}$  seems consequently to be in equally close connection with eight atoms of  $\text{Na}$ ; it has exactly the same relation to these eight atoms. It appears therefore as *octavalent*, certainly not as univalent; for it would be entirely arbitrary to suppose any two neighbouring atoms of  $\text{NaCl}$  in an especially close connection and to take this couple for the chemical molecule of  $\text{NaCl}$ . By this example we see that from Mr. Barlow's point of view both the notion of chemical valency and of chemical molecule completely lose their present import for the crystallised state. This objection, of course, will not destroy the theory of Mr. Barlow, since chemical valency does not yet belong to perfectly clear and fixed notions, and since the idea of the chemical molecule in a crystal is also not evident and clear. The author, however, is at all events obliged to show why these two notions, of such great moment for substances in a gaseous state, should become completely insignificant, as soon as crystallised bodies are in question.

Finally for a physical objection. With respect to the fact that most substances change their volume in congealing, Mr. Barlow admits that the atoms themselves undergo an expansion (positive or negative) in the act of crystallisation. Thus he attributes to the atoms variability of volume, i.e. one of those qualities, for the explanation of which the atomic theory has been devised. Well, let it be so, but this hypothesis of atomic expansion is not even found sufficient everywhere, but must be assisted occasionally by auxiliary hypotheses. Thus for explaining the isomorphism of substances which contain atoms of the same kind (e.g.  $\text{CaCO}_3$  and  $\text{FeCO}_3$ ) Mr. Barlow supposes that the expansion in the act of crystallising is confined to the common atoms, whilst the different atoms in both substances remain unaltered.

All these objections do not overthrow the author's theory, but they shake it. Perhaps they will induce Mr. Barlow to establish

